DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

TCC Source Protection Region

Draft Tier 2 Water Budget Analysis Lake Ontario Subwatersheds 1 and 3 (Colborne and Brighton)

Meeting Presentation – Nov. 23, 2009

Dirk Kassenaar, M.Sc., P.Eng.
Earthfx Inc.

Earthfx Incorporated

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Presentation Outline

- Tier 2 Water Budget Objectives
- Overview of Selected Approach
  - Subwatershed assessment areas
  - Modelling approach
- Summary of Tier 2 Water Budget Components
  - Water Demand, Supply, Reserve
- Stress Assessment Results
- Uncertainty Assessment
- Conclusions

Tier 2 Water Budget: Objectives

- Objective: Conduct a Tier 2 stress assessment of the target watersheds
  - Lake Ontario Subwatersheds 1 and 3
    - Also known as Proctor 1 and 3
    - Proctor 1 – includes Colborne Municipal Wells
    - Proctor 3 – includes Brighton Municipal Wells
  - Use South Slope Model (developed for WHPA SWAT Analysis)
    - Include conversion to transient modelling
    - Use updated actual water takings
      - SWAT analysis based on permitted rates

Tier 2 Water Budget: Approach

1. **Review Assessment Areas**
2. **Water Supply estimate:**
   - Recharge Q_r: estimate from ORM recharge model simulation
   - Lateral inflow Q_{in}: estimate from lateral MODFLOW fluxes
3. **Water Reserve:** Estimate from MODFLOW stream discharge
   - Previously estimated using analytical approximations
4. **Water Demand:** Use actual takings estimates from MOE
   - Based on an earlier York Region water use survey
5. **Calculate** “% Water demand” and stress level
6. **Assess uncertainty** if close to threshold

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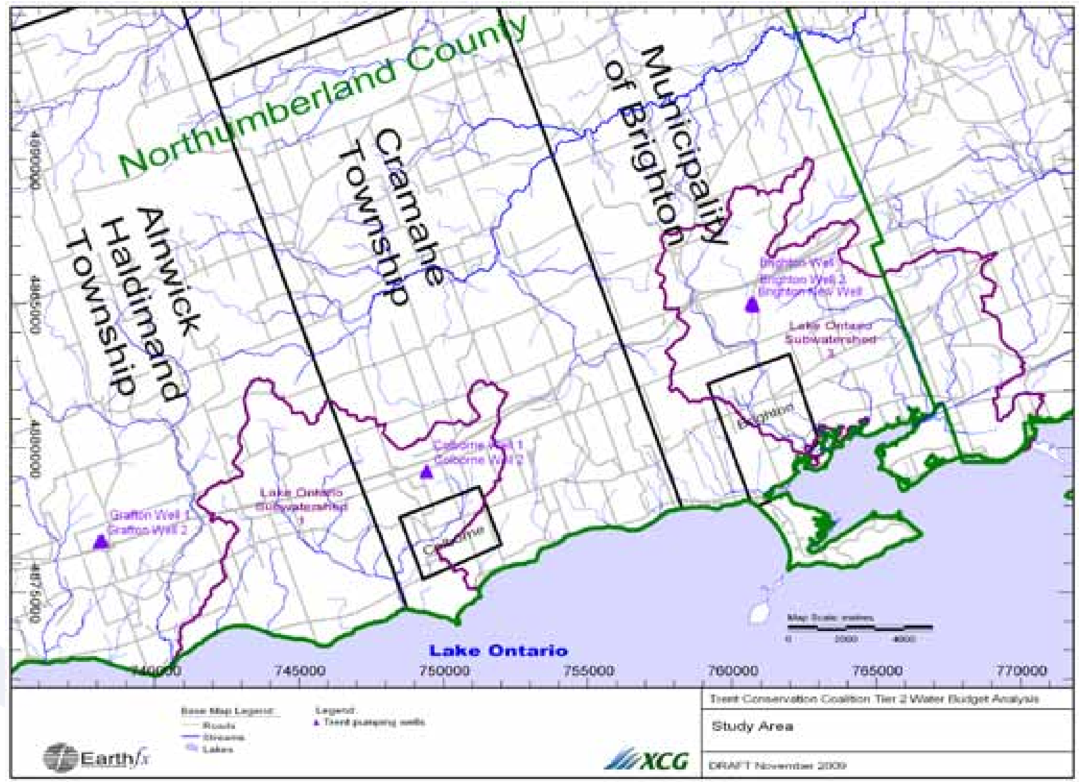
Study Area:

- **Tier 1 Catchment Area(km2)**
- Proctor 1 66.2
- Proctor 3 81.6
- Guidance recommends 20 to 100 km2 assessment areas



Existing Modelling Tools

- South Slope Model
  - 6 Layers, 25 m (in wellfield) to 100 m cell size
  - Full simulation of all stream segment discharge
  - Multi-watershed model (allows estimate of lateral inflows and outflows)
  - Steady state (average annual) simulation updated to transient
- Recharge Estimate
  - Recharge estimate based on ORM Core Model geology based recharge, updated to match local gauges
  - Tier 1 recharge based on older CAMC Regional model

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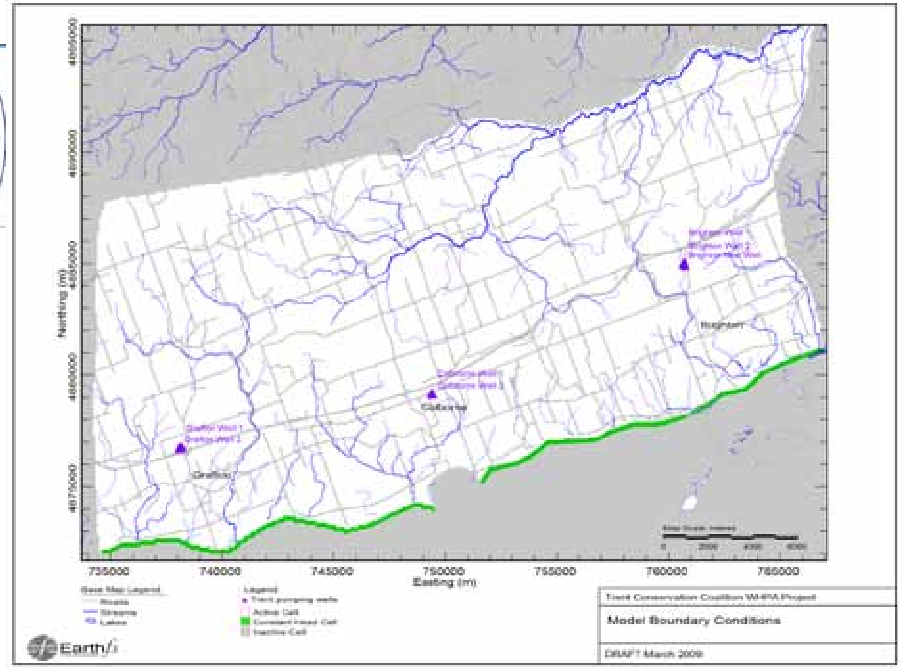
South Slope Model

- Model extends north of assessment catchments
  - Lateral inflows can be estimated from model
- Qin calculation approach used (not Qnet, like in the Tier 1)



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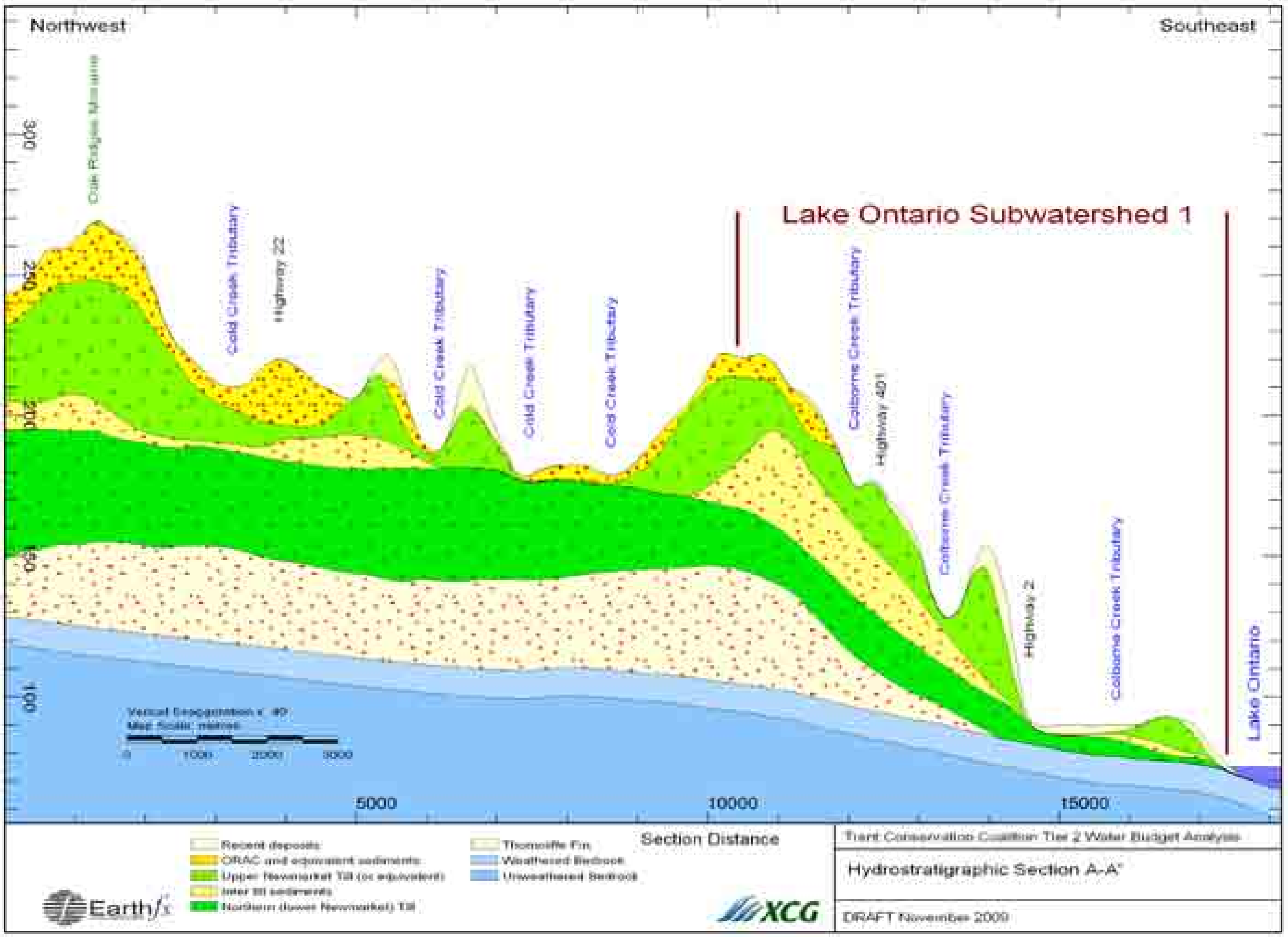
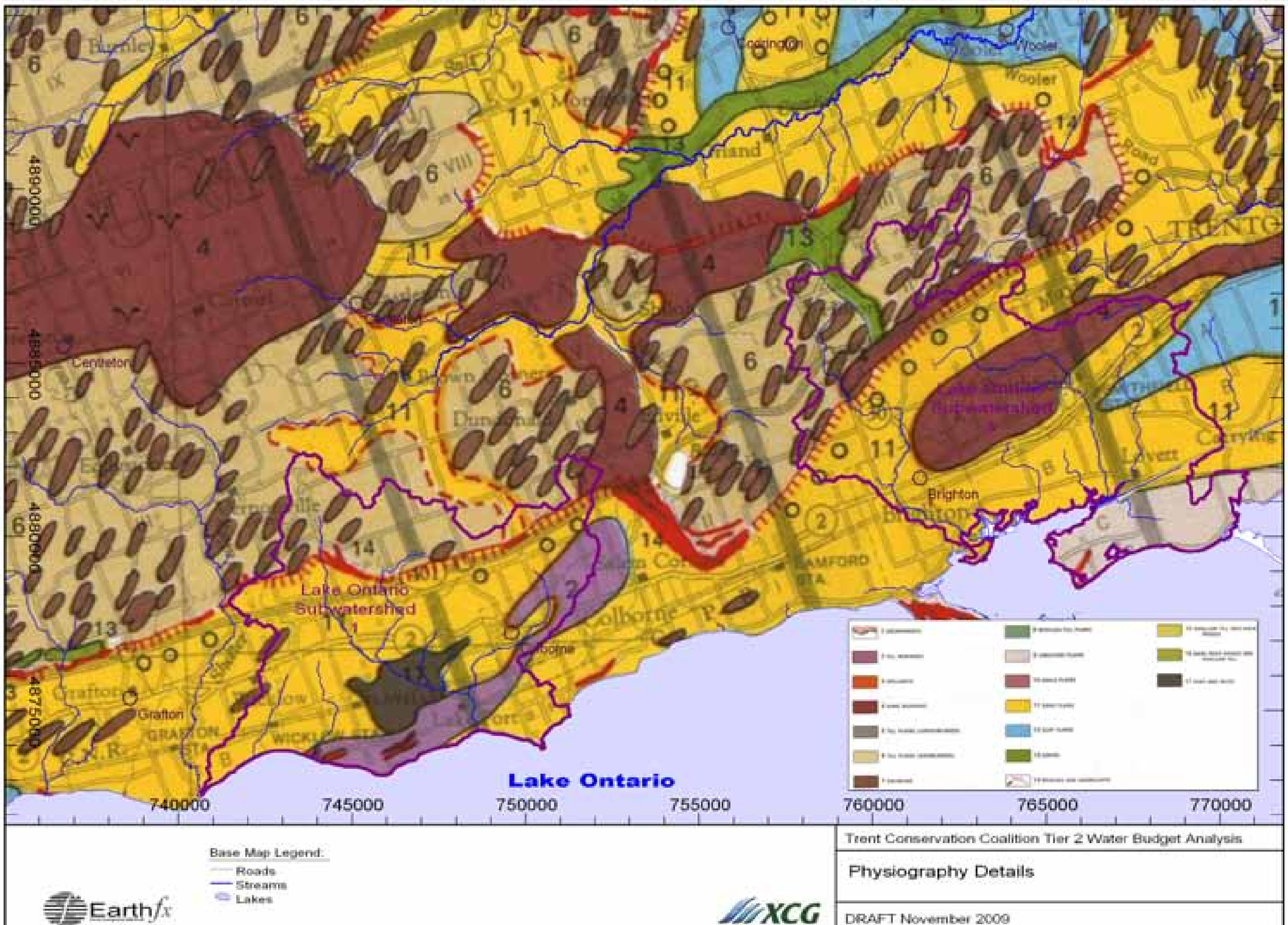
South Slope Model



South Slope Model: Physiography



Tier 2 Water Budget for the Lake Ontario Watersheds

WATER DEMAND ESTIMATES

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Consumptive Demand Estimate (Current Conditions Proctor 1)

- Consumptive demand estimate from Tier 1 assessment used
- Municipal consumption relative to the aquifer

Water Taking Summary - Proctor 1									
Permit Number	Well Name	Type Of Use	Year Reported	Pop	Actual Pumping L/Day	Months Of Taking	m^3/yr	Consump-tive Factor	Consump-tive Demand
Municipal wells: Colborne									
91-P-3010	Colbrorne Well 1	Municipal			1,641,600	12	599,184	1	599,184
	Colbrorne Well 2	Municipal			1,641,600	12	599,184	1	599,184
TOTALS:									
Non-Municipal wells									
5471-6E8HNV	Quarry Sump A	Pits and Quarries	2005		1,417,904	12	517,535	0.25	129,384
5471-6E8HNV	Quarry Sump A	Pits and Quarries	2006		6,659,110	12	2,430,575	0.25	607,644
TOTALS: (Max Year = 2006)									
Unserviced domestic use		Other - Water Supply		3313	1,109,855	12	405,097	0.2	81,019
Agricultural use		Other - Agriculture			244,336	12	89,183	0.8	71,346

Consumptive Demand Estimate (Current Conditions Proctor 3)

Water Taking Summary - Proctor 3									
Permit Number	Well Name	Type Of Use	Year recorded	Pop	Actual Pumping L/Day	Months Of Taking	m³/yr	Consump-tive Factor	Consump-tive Demand
Municipal wells: Brighton									
2001-62MNU2	PW1	Municipal			1,007,277	12	367,656	1	367,656
	PW2	Municipal			722,614	12	263,754	1	263,754
	PW3	Municipal			976,605	12	356,461	1	356,461
TOTALS:									
Non-Municipal wells									
01-P-4011	Club House Well	Golf Course Irrigation	2005		988	4	361	0.7	252
	Club House Well	Golf Course Irrigation	2006		1,374	4	502	0.7	351
	Club House Well	Golf Course Irrigation	**2007**		1,491	4	544	0.7	381
	Dug Pond	Golf Course Irrigation	2005		180,307	4	65,812	0.7	46,068
	Dug Pond	Golf Course Irrigation	2006		217,440	4	79,366	0.7	55,556
	Dug Pond	Golf Course Irrigation	**2007**		297,123	4	108,450	0.7	75,915
	Smithfied Creek	Golf Course Irrigation	2005		93,408	4	34,094	0.7	23,866
	Smithfied Creek	Golf Course Irrigation	2006		124,905	4	45,590	0.7	31,913
	Smithfied Creek	Golf Course Irrigation	**2007**		191,939	4	70,058	0.7	49,040
0881-62WKX5	Well	Aggregate Washing	2006		235,419	7	85,928	0.25	21,482
	Well	Aggregate Washing	**2007**		337,394	7	123,149	0.25	30,787
96-P-4076		Bottled Water	Max permit		113,530	12	41,438	1	41,438
TOTALS: (Max year 2007)									
Unserviced domestic use		Other - Water Supply		6880	2,304,800	12	841,252	0.2	168,250
Agricultural use		Other - Agriculture			322,466	12	117,700	0.8	94,160
GRAND TOTALS:									

Seasonal Demand Estimate (Current Conditions Proctor 3)

Water Taking Summary - Proctor 3

Permit Number	Well Name	Type Of Use	Year recorded	Months Of Taking	Consump-tive Factor	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total (m^3)
Municipal wells: Brighton																		
2001-62MNU2	PW1	Municipal		12	1	31,204	28,436	31,204	30,198	31,204	30,198	31,204	31,204	30,198	31,204	30,198	31,204	367,656
	PW2	Municipal		12	1	22,386	20,400	22,386	21,664	22,386	21,664	22,386	22,386	21,664	22,386	21,664	22,386	263,754
	PW3	Municipal		12	1	30,254	27,570	30,254	29,278	30,254	29,278	30,254	30,254	29,278	30,254	29,278	30,254	356,461
TOTALS:						83,844	76,406	83,844	81,139	83,844	81,139	83,844	83,844	81,139	83,844	81,139	83,844	987,871
Non-Municipal wells																		
01-P-4011	Club House Well	Golf Course Irrigation	2005	4	0.7	-	-	-	-	-	63	63	63	63	-	-	-	252
	Club House Well	Golf Course Irrigation	2006	4	0.7	-	-	-	-	-	88	88	88	88	-	-	-	351
	Club House Well	Golf Course Irrigation	**2007**	4	0.7	-	-	-	-	-	95	95	95	95	-	-	-	381
	Dug Pond	Golf Course Irrigation	2005	4	0.7	-	-	-	-	-	11,517	11,517	11,517	11,517	-	-	-	46,068
	Dug Pond	Golf Course Irrigation	2006	4	0.7	-	-	-	-	-	13,889	13,889	13,889	13,889	-	-	-	55,556
	Dug Pond	Golf Course Irrigation	**2007**	4	0.7	-	-	-	-	-	18,979	18,979	18,979	18,979	-	-	-	75,915
	Smithfied Creek	Golf Course Irrigation	2005	4	0.7	-	-	-	-	-	5,966	5,966	5,966	5,966	-	-	-	23,866
	Smithfied Creek	Golf Course Irrigation	2006	4	0.7	-	-	-	-	-	7,978	7,978	7,978	7,978	-	-	-	31,913
	Smithfied Creek	Golf Course Irrigation	**2007**	4	0.7	-	-	-	-	-	12,260	12,260	12,260	12,260	-	-	-	49,040
0881-62WKX5	Well	Aggregate Washing	2006	7	0.25	-	-	-	-	3,069	3,069	3,069	3,069	3,069	3,069	3,069	-	21,482
	Well	Aggregate Washing	**2007**	7	0.25	-	-	-	-	4,398	4,398	4,398	4,398	4,398	4,398	4,398	-	30,787
96-P-4076		Bottled Water	Max permit	12	1	3,517	3,205	3,517	3,404	3,517	3,404	3,517	3,517	3,404	3,517	3,404	3,517	41,438
TOTALS: (Max year 2007)						3,517	3,205	3,517	3,404	7,915	39,136	39,249	39,249	39,136	7,915	7,802	3,517	197,562
Unserviced domestic use		Other - Water Supply		12	0.2	14,280	13,013	14,280	13,819	14,280	13,819	14,280	14,280	13,819	14,280	13,819	14,280	168,250
Agricultural use		Other - Agriculture		12	0.8	7,992	7,283	7,992	7,734	7,992	7,734	7,992	7,992	7,734	7,992	7,734	7,992	94,160
GRAND TOTALS:						109,633	99,907	109,633	106,096	114,031	141,828	145,365	145,365	141,828	114,031	110,494	109,633	1,447,843

Consumptive Demand Estimate Summary

Current Groundwater Consumption (m³/a)					
Watershed Name	Municipal	Domestic	PTTW	Agricultural	Total Consumption
Proctor 1	1,198,368	81,019	607,644	71,346	1,958,377
Proctor 3	987,871	168,250	197,562	94,160	1,447,843

Future Groundwater Consumption (m³/a)					
Watershed Name	Municipal	Domestic	PTTW	Agricultural	Total Consumption
Proctor 1	1,438,042	101,274	607,644	71,346	2,218,306
Proctor 3	1,185,445	210,313	197,562	94,160	1,687,480

Unserviced Water Consumption Estimates					
Watershed Name	Current Scenario		Estimated Growth	Future Scenario	
	Population	Consumptive Use	%	Population	Consumptive Use
Proctor 1	3,313	405,097	25	4,141	506,341
Proctor 3	6,880	841,252	25	8,600	1,051,565

Tier 2 Water Budget for the Lake Ontario Watersheds

WATER SUPPLY ESTIMATES

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Water Supply Estimate

- Recharge: Estimate from surficial geology and ORM Simulations
  - Locally refined through gauge calibration
- Lateral Inflows (Qin)
  - MODFLOW GW flux crossing the subwatershed boundary
- Water Reserve
  - 10% of the baseflow discharge calculated by the MODFLOW

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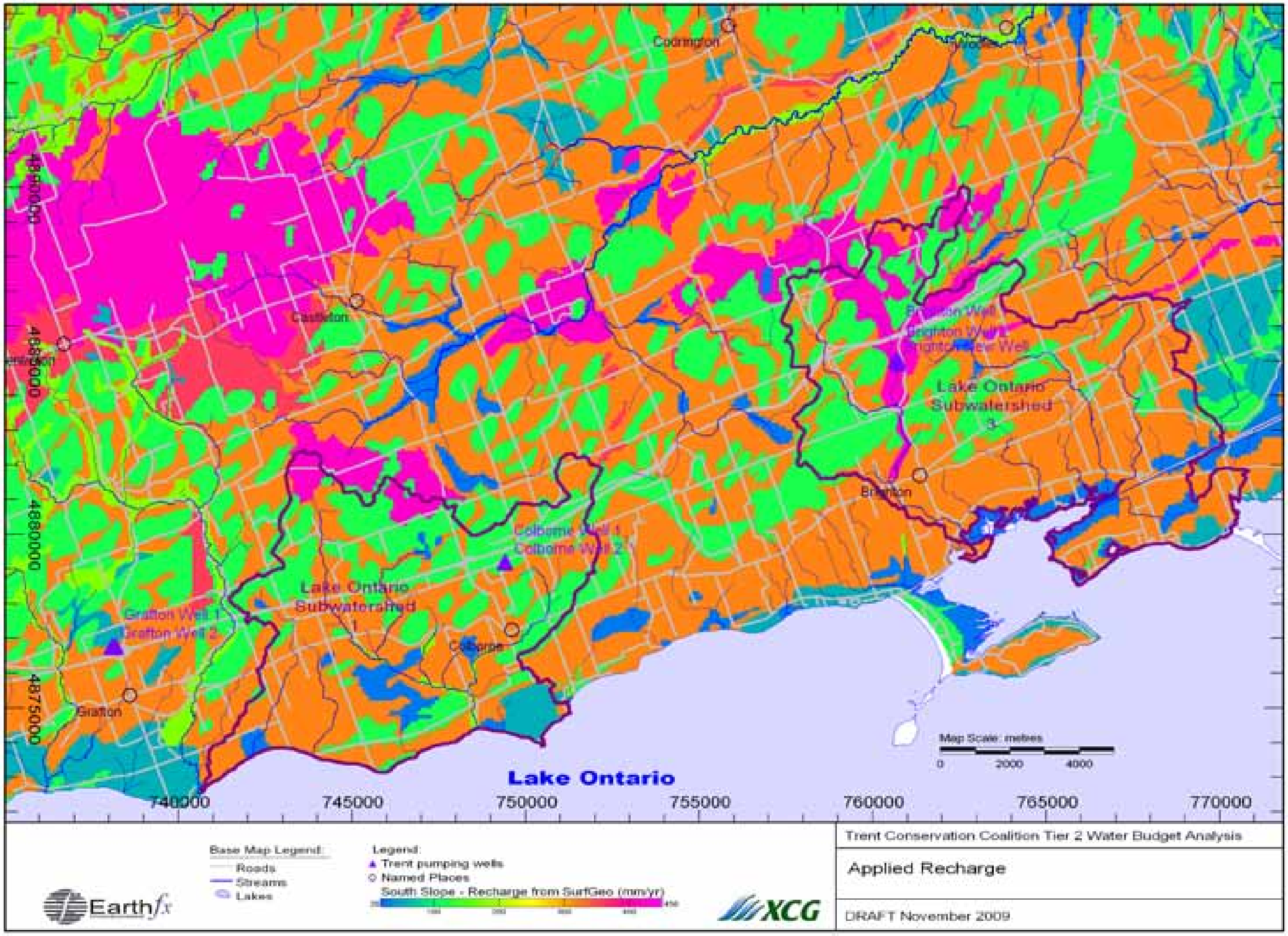
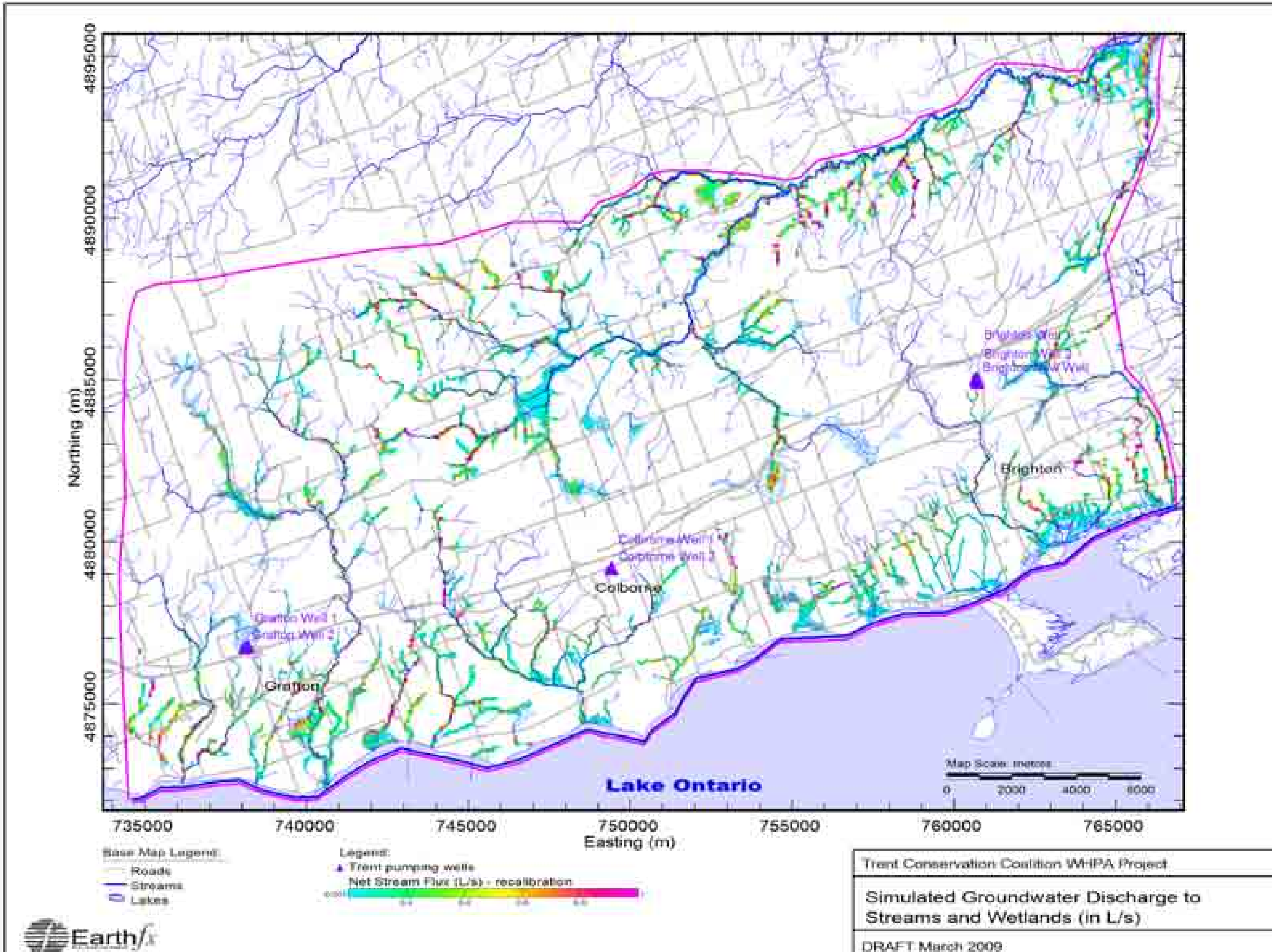
Recharge

- Recharge estimated from surficial geology, using ORM results as a base, but locally refined during calibration



GW Discharge to Streams



Water Budget Components: Discussion

- Lateral inflows are a significant component of the GW Supply term
  - Q_{in} equals 58% of recharge in Proctor 1 watershed
    - Lateral inflow from ORM to the north
  - Q_{in} equals 19% of recharge in Proctor 3 watershed
- Reserve estimated as 10% of the MODFLOW baseflow discharge
  - Qbaseflow equals 119% of recharge in Proctor 1 watershed
    - More baseflow discharge than recharge
    - Lateral inflow from the ORM in the north
  - Qbaseflow equals 67% of recharge in Proctor 3 watershed
    - Recharge loss of flow to Cold Creek to the north and east

Tier 2 Water Budget for the Lake Ontario Watersheds

Subwatershed Stress Assessment

Tier 1 – Stress Levels

$$\textit{\% Water Demand} = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100$$

Note: $Q_{supply} = Q_{recharge} + Q_{lateral\ inflow}$

Surface Water Stress Levels

Stress Level Assignment	Maximum Monthly % Water Demand
Significant	^{3} 50%
Moderate	^{3} 20%
Low	0 - 19 %

Groundwater Stress Levels

Stress Level Assignment	Average Annual % Water Demand	Maximum Monthly % Water Demand
Significant	^{3} 25%	^{3} 50%
Moderate	^{3} 10%	^{3} 25%
Low	0 - 9%	0 - 24%

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Stress Assessment Results: Current Conditions

Current Stress Assessment														
Subwatershed	Area	Model Recharge		Qin		Baseflow			Reserve (median flow)		Groundwater consumption		GW Stress
	km^2	mm/a	m^3/s	m^3/s	mm/a	l/sec	mm/a	m^3/s	mm/a	m^3/s	m^3/a	mm/a	%
Proctor 1	66.2	229	0.48	0.27	127	570	272	0.57	27	0.057	1,958,377	29.6	9%
Proctor 3	81.6	261	0.68	0.13	49	455	176	0.46	18	0.046	1,447,843	17.7	6%

- Low stress levels
- Proctor 1 in the 8%-10% uncertainty assessment range

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Stress Assessment Results: Future Conditions

Future Stress Assessment														
Subwatershed	Area	Model Recharge		Qin		Baseflow			Reserve (median flow)		Groundwater Consumption		GW Stress
	km^2	mm/a	m^3/s	m^3/s	mm/a	l/sec	mm/a	m^3/s	mm/a	m^3/s	m^3/a	mm/a	%
Proctor 1	66.2	229	0.48	0.27	127	570	272	0.57	27	0.057	2,218,306	33.5	10%
Proctor 3	81.6	261	0.68	0.13	49	455	176	0.46	18	0.046	1,687,480	20.7	7%

- Moderate stress level for Proctor 1 under Future Conditions

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Stress Assessment: Monthly

Stress Assessment (current) - January											
Subwatershed	Month	Area	Recharge	Qin	Baseflow		Reserve (median flow)		Groundwater Consumption		GW Stress
		km^2	mm/mo	mm/mo	mm/mo	m^3/s	mm/mo	m^3/s	m^3/mo	mm/mo	%
Proctor 1	Jan	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Feb	66.2	19.1	10.6	19.1	0.49	2.26	0.058	151,469	2.29	8%
	Mar	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Apr	66.2	19.1	10.6	19.1	0.49	2.26	0.058	160,852	2.43	9%
	May	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Jun	66.2	19.1	10.6	19.1	0.49	2.26	0.058	160,852	2.43	9%
	Jul	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Aug	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Sep	66.2	19.1	10.6	19.1	0.49	2.26	0.058	160,852	2.43	9%
	Oct	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
	Nov	66.2	19.1	10.6	19.1	0.49	2.26	0.058	160,852	2.43	9%
	Dec	66.2	19.1	10.6	19.1	0.49	2.26	0.058	166,214	2.51	9%
Proctor 3	Jan	81.6	21.8	4.1	21.8	0.68	1.47	0.046	109,633	1.34	6%
	Feb	81.6	21.8	4.1	21.8	0.68	1.47	0.046	99,907	1.22	5%
	Mar	81.6	21.8	4.1	21.8	0.68	1.47	0.046	109,633	1.34	6%
	Apr	81.6	21.8	4.1	21.8	0.68	1.47	0.046	106,096	1.30	5%
	May	81.6	21.8	4.1	21.8	0.68	1.47	0.046	114,031	1.40	6%
	Jun	81.6	21.8	4.1	21.8	0.68	1.47	0.046	141,828	1.74	7%
	Jul	81.6	21.8	4.1	21.8	0.68	1.47	0.046	145,365	1.78	7%
	Aug	81.6	21.8	4.1	21.8	0.68	1.47	0.046	145,365	1.78	7%
	Sep	81.6	21.8	4.1	21.8	0.68	1.47	0.046	141,828	1.74	7%
	Oct	81.6	21.8	4.1	21.8	0.68	1.47	0.046	114,031	1.40	6%
	Nov	81.6	21.8	4.1	21.8	0.68	1.47	0.046	110,494	1.35	6%
	Dec	81.6	21.8	4.1	21.8	0.68	1.47	0.046	109,633	1.34	6%

Note: Values rounded for presentation purposes

25 - 50% of available supply being taken

50% or more of available supply being taken

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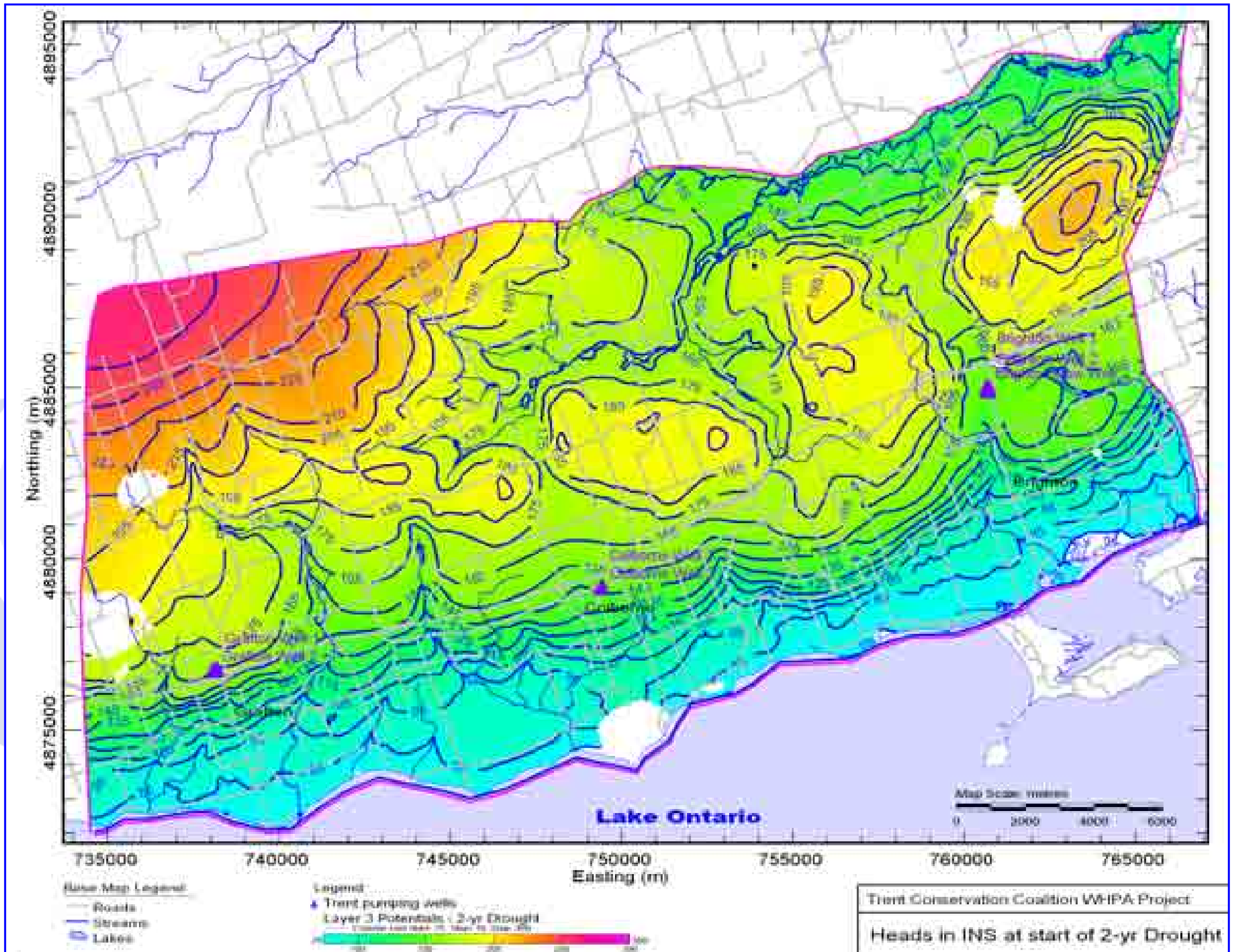
Stress Assessment: Demand uncertainty

- Technical Rules 35 (2) Section H (MOE, 2008, page 24) indicates that sensitivity analysis might justify a “moderate” stress level for subwatersheds where the water demand is between 8% and 10%.
- Results are close to the thresholds, and need to be checked with the project team
    - Need to discuss sensitivity assessment approach

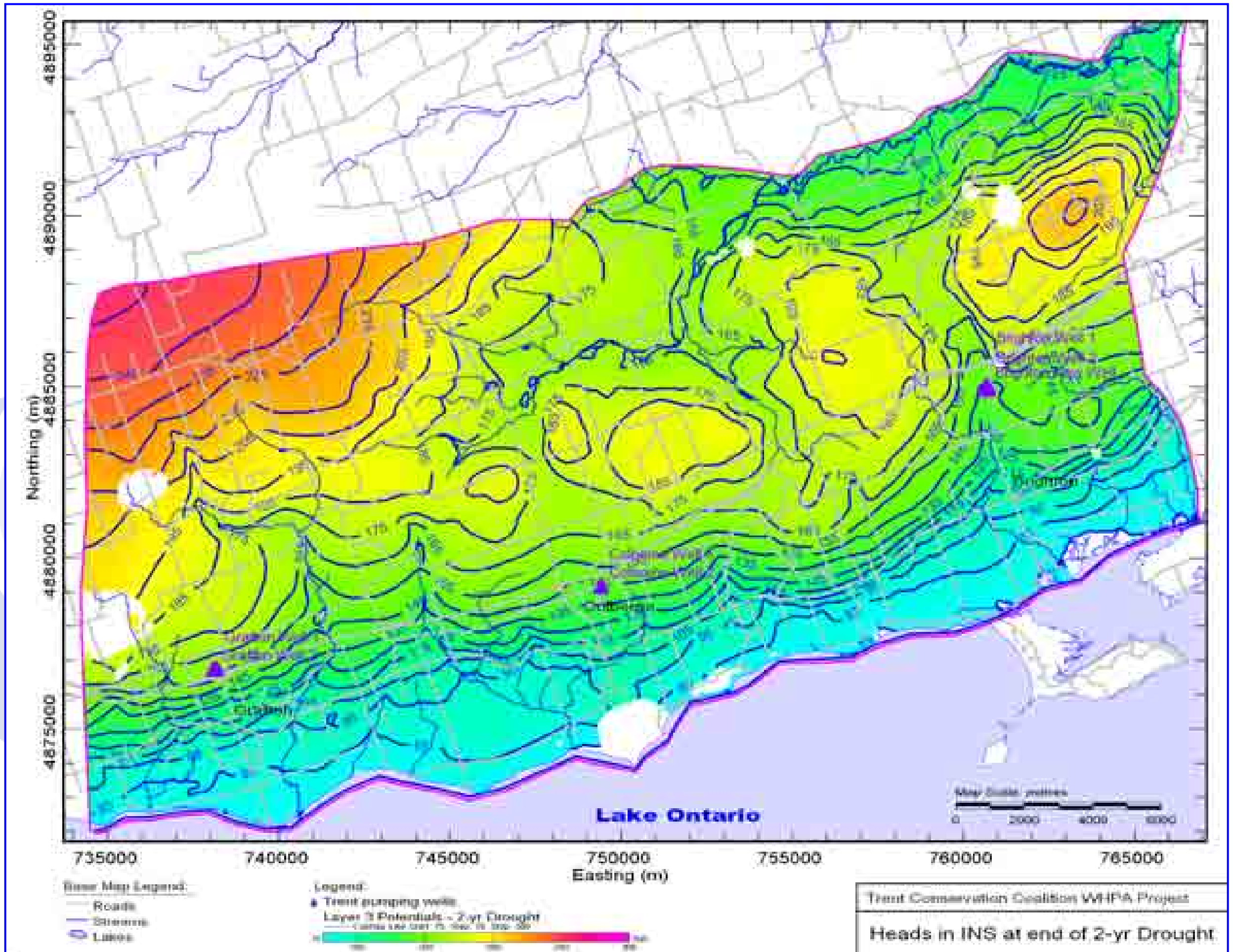
Transient Assessment: Sustainability of Well Operations during 2 year drought

- Approach: 2 year transient simulation with no recharge
- If well goes “dry”, proceed with a 10 year simulation

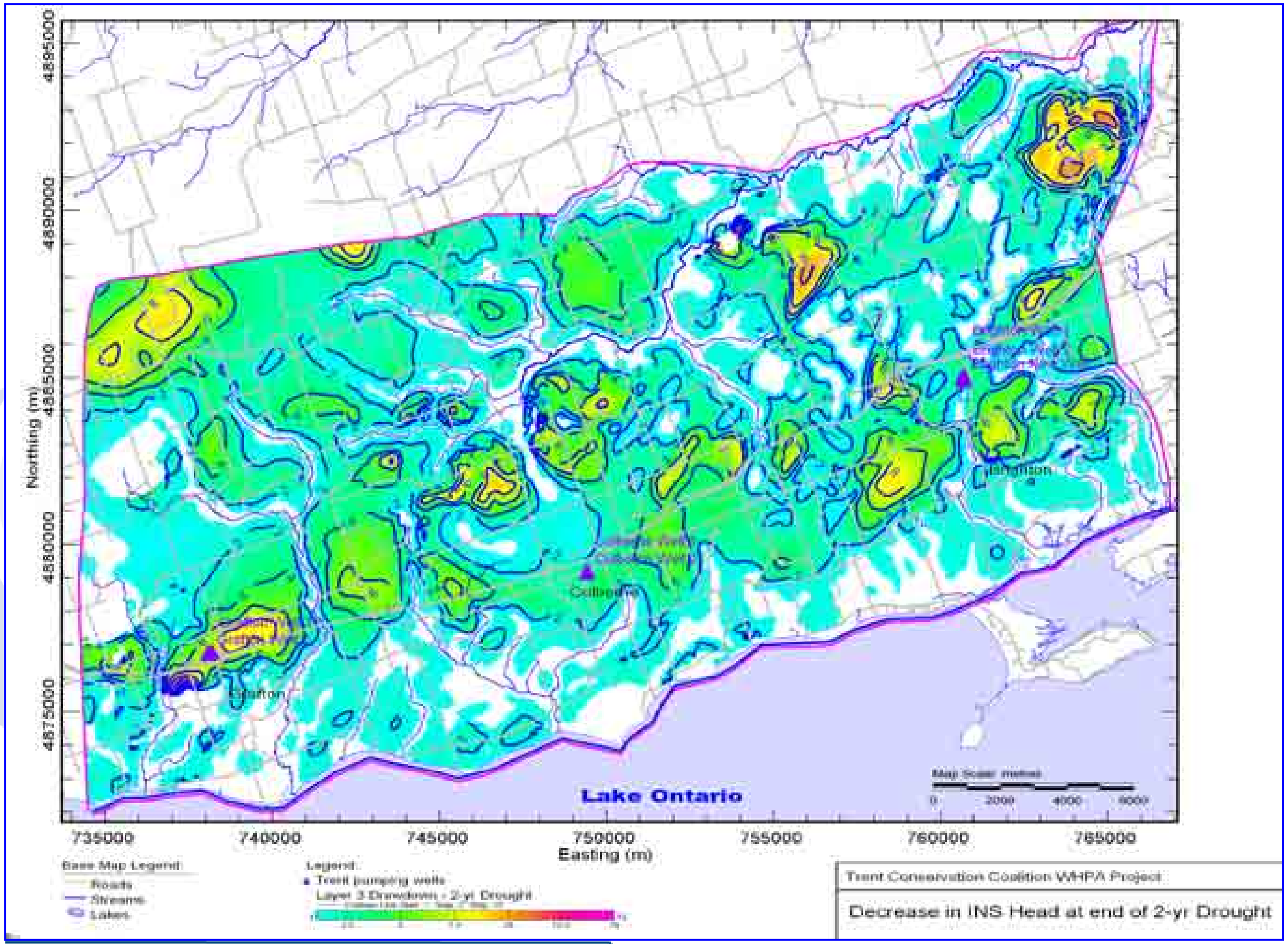
Heads in the INS at start of 2-year Drought



Heads in the INS at end of 2-year Drought



Drawdown in the INS at end of 2-year Drought



Transient Simulation Conclusions

- Proctor 1 – Colborne Wells
  - Deep wells, lots of available drawdown
  - 2 year drought does not pose a threat to operations
- Proctor 3 – Brighton Wells
  - Shallower wells, but in a discharge area, so not sensitive to drought conditions
  - Also, no threat under 2 year drought conditions

Tier 2 Water Budget for the Lake Ontario Watersheds

CONCLUSIONS

Tier 2 Water Budget Conclusions

- Actual water use estimates still variable and somewhat uncertain, but better than Tier 1
  - Quarry in Proctor 1 is most significant water use
  - Multiple permits in Proctor 3, some obvious errors in actual use data
  - Recommend team and peer review of actual water use estimates
- Stress levels are significantly reduced from the Tier 1, because:
  - Qin significantly increases Qsupply term (Qin=56% of Qr)
  - Qrecharge in Proctor 3 has increased based on the new model calibration
- Proctor 1 Subwatershed at Moderate Level under Future Conditions
  - Consider move to Tier 3